PATTERN FORMING MATERIALS AND PATTERN FORMATION METHOD USING THE MATERIALS

Technical Field

The present invention relates to micromachining of a substrate, and more particularly, to a material for use in forming a fine pattern on a substrate and a method of forming a fine pattern using the material.

Background Art

Intensive research on fine patterning methods, such as photolithography, using vacuum ultraviolet rays (VUV) or X-rays, which are applied in the manufacture of semiconductor integrated circuits or electronic/electrical parts, including optical discs, has been conducted. Fine pattern structures with a line width of 0.1 m can be realized in current situations based on such patterning techniques, and their commercialization is expected in a few years.

A conventional method of forming a resist pattern in the manufacture of electronic/electrical parts involves activation light irradiation onto a photoresist layer through a predetermined mask pattern and development. Accordingly, the minimal dimensions of the resist pattern is limited, in practice, to be slightly smaller than the wavelength of activation light used, due to diffraction of the activation light. The diffraction limit relies on the wavelength of light and the numerical aperture of a lens used. Shorter wavelength of light and greater numerical aperture of a lens are more effective to reduce the diffraction limit. However, since increasing the numerical aperture of the lens has encountered limitations in the current technical status, there are more trends toward using shorter wavelength light to form smaller resist patterns.

New exposure technology using deep UV, laser light, or soft X-ray has been researched. In current situations, it is possible to form a fine

pattern of about 150 nm in size using KrF eximer laser or ArF eximer laser. However, there are needs for improvements in accompanying techniques, for example, regarding the development of high-performance light sources, or property improvements of optical materials or resist materials. Furthermore, there are also needs for technology that allows for the use of smaller light sources or optical systems and saves energy.

Electron beam lithography ensures much finer pattern processing for a few nanometer pattern dimension compared to photolithography. However, electron beam lithography requires an additional vacuum enclosure, a large electrode, and a high power source for electron acceleration or deflection. Also, the use of a high accelerating voltage of tens of kilovolts raises safety concerns.

In addition, using smaller wavelength of light or electron beam to form fine patterns in the above-described techniques is cost high. To overcome such defects in the conventional fine pattern formation methods, various methods of forming fine patterns have been suggested. For example, Japanese Patent Application No. hei 8-249493 discloses a pattern formation method in which the crystalline state of chalcogenide is thermally changed by laser light irradiation. This fine patterning method is based on variation in etch rate between different crystalline states and ensures patterning to be smaller than the diffraction limit. However, the variation in etch rate depending on crystalline states is not large enough, and the uneven chalcogenide layer leads to varying etch rates even for the same crystalline state. Moreover, a chalcogenide layer is etched first at an intercrystalline domain so that a quality fine pattern is not guaranteed. In addition, chalcogenide, which is an essential material of the disclosure, cannot be applied to form a fine pattern for semiconductors. Other problems arise from the change of the chalcogenide.

A pattern forming material which thermally changes by activation light irradiation and a patterning method using the material are suggested (Microelectronic Engineering 61-62, 2002, p. 415-421). In

this disclosure, a light-to-heat converting material layer made of $Ge_2Sb_2Te_5$ is interposed between a target substrate and a photoresist layer to be patterned and is subjected to activation light irradiation to generate heat. The heat generated in the $Ge_2Sb_2Te_5$ layer is transferred to the overlying photoresist layer to induce chemical reactions and form a fine pattern therein. A pattern of 100 nm can be formed with this method. In addition, since a low cost semiconductor laser is used as an activation light source and energy consumption is small, compared to techniques which require costly high-performance light sources, such as KrF eximer laser, ArF eximer laser, or electron beams, the disclosed method is regarded to be very economical and offers higher processing precision and finer pattern processing ability compared to the method using chalcogenide.

However, the above resist patterning method using the light-to-heat converting material layer has the following limitations. The amount of heat transferred from the light-to-heat converting layer to the photoresist layer is not enough to form a desired fine pattern. The maximum pattern height that can be obtained with this method is limited to 30 nm when the width of a pattern is designed at 100 nm. In other words, this method cannot be applied to form a high aspect ratio pattern on a substrate. When the intensity of laser light radiated is increased to generate larger amount of heat or for higher processing rate or greater pattern height, the photoresist layer undesirably evaporates and disappears.

Disclosure of the Invention

The present invention provides new pattern forming materials useful for a high aspect ratio fine pattern and a pattern formation method using the materials.

The present invention provides a method of efficiently forming a high aspect ratio fine pattern in a thermal sensitive material layer formed on a target substrate using heat generated at first and second

light-to-heat converting layer formed on both surfaces of the thermal sensitive material layer, via activation light irradiation.

In accordance with an aspect of the present invention, there are provided pattern forming materials comprising: a thermal sensitive material layer formed on a target substrate; a first light-to-heat converting layer formed between the thermal sensitive material layer and the target substrate; and a second light-to-heat converting layer formed on a surface of the thermal sensitive material layer opposite to the first light-to-heat converting layer, the thermal sensitive material layer being interposed between the first and second light-to-heat converting layers.

In accordance with another aspect of the present invention, there is provided a method of forming fine patterns using the above pattern forming materials.

According to the present invention, since the photo and thermal sensitive material layer is interposed between the first and second light-to-heat converting layers, both surfaces of the photo and thermal sensitive material layer are efficiently heated by activation light irradiation without evaporation or deformation thereof. A resulting fine pattern has a whole shape and a higher aspect ratio.

Brief Description of the Drawings

FIG. 1 is a sectional view illustrating an exemplary structure of pattern forming materials and the principle of patterning using the pattern forming materials according to the present invention;

FIG. 2 is a graph of light intensity and temperature distributions when activation light is incident on a light-to-heat converting layer;

FIGS. 3 and 4 are sectional views illustrating a method of forming a fine pattern according to a second embodiment of the present invention;

FIGS. 5 and 6 are sectional views illustrating a method of forming a fine pattern according to a third embodiment of the present invention;

FIGS. 7 and 8 are sectional views illustrating a method of forming

a fine pattern according to a fourth embodiment of the present invention;

FIGS. 9 and 10 are sectional views illustrating a method of forming a fine pattern according to a fifth embodiment of the present invention;

FIGS. 11 and 12 are sectional views illustrating a method of forming a fine pattern according to a sixth embodiment of the present invention; and

FIG. 13 illustrates the result of an atomic force microscopic observation on a fine pattern formed in a seventh embodiment of the present invention.

Best mode for carrying out the Invention

Hereinafter, embodiments of the present invention will be described in detail with reference to the appended drawings.

< Embodiment 1 >

FIG. 1 illustrates an exemplary structure of pattern forming materials according to the present invention and the principle of forming a fine pattern using the pattern forming materials. The pattern forming materials of FIG. 1 include a first light-to-heat converting layer 3, a first thermal buffer layer 4, a photo and thermal sensitive material layer 5, a second thermal buffer layer 6, a second light-to-heat converting layer 7, and a cap layer 8, which are sequentially stacked upon one another, with a substrate protective layer 2 between the first light-to-heat converting layer 3 and a target substrate 1. When activation light 10 is radiated onto the pattern forming materials having the above structure via a lens 9, the energy of the activation light 10 is converted into heat 11 by the function of the first and second light-to-heat converting layers 3 and 7. The heat 11 is transferred via the first and second thermal buffer layers 4 and 6 to heat a pattern portion 12 of the photo and thermal sensitive material layer 5 and induce chemical reaction therein. Although the activation light 10 is illustrated as being radiated through the target

substrate 1, the activation light 10 may be radiated in a direction opposite to the target substrate 1 if necessary. The thickness of each layer is determined to be in a range of 2-200 nm. However, each layer may be formed to be thinner or thicker than the above range depending on a desired pattern size or the material composing the photo and thermal sensitive material layer 5.

The activation light 10 is not fully absorbed by the first light-to-heat converting layer 3, and a large portion of the activation light 10 transmits the first light-to-heat converting layer 3. The transmitted portion of the activation light 10 is absorbed and converted into heat by the second light-to-heat converting layer 7. Comparing to conventional one having only one light-to-heat converting layer, the activation light 10 can be more efficiently converted into heat even at a low output power. Therefore, a conventional problem that the photo and thermal sensitive material layer evaporates due to an excess increase in the output power of the activation light does not arise. As such, the activation light 10 is absorbed and converted into heat by the first and second light-to-heat converting layers 3 and 7. The heat converted from the activation light 10 conducts to the photo and thermal sensitive material layer 5 to induce chemical reaction in the pattern portion 12. Subsequently, a reaction domain or a non-reaction domain is etched away to form a desired pattern.

The principle enabling patterns finer than the diffraction limit of activation light used to be formed is illustrated in FIG. 2.

FIG. 2 is a graph of light intensity and temperature distributions when activation light is incident on a light-to-heat converting layer. Referring to FIG. 2, activation light 21 incident on the light-to-heat converting layer with a spot diameter 20 has a Gaussian intensity distribution 22 where the intensity is peak at the spot center. The temperature of the light-to-heat converting layer has a Gaussian distribution. A region 24 is an effective region of the photo and thermal sensitive layer 5 (refer to FIG. 1) where chemical reaction is induced due

to a high temperature and is narrower than the spot diameter 20. The Gaussian temperature distribution of the light-to-heat converting layer 22 that renders a reaction region narrower than the spot diameter 21 is important. Based on such a temperature distribution of the first and second light-to-heat converting layer 3 and 7 of FIG. 1, the intensity of activation light or activation light irradiation duration may be further varied to control the heat generation in the first and second light-to-heat converting layers 3 and 7. As a result, thermal chemical reaction is induced only in a small region of the photo and thermal sensitive material layer that is irradiated by the spot center of the activation light, thereby enabling patterns finer than the diffraction limit of the activation light to be formed.

In a conventional structure including only one light-to-heat converting layer beneath a photo and thermal sensitive material layer, a limited amount of heat is transferred to the photo and thermal sensitive material layer so that thermal reaction therein is not sufficient to form a high aspect ratio fine pattern. However, according to the present invention, since the photo and thermal sensitive material layer 5 is inserted between the first and second light-to-heat converting layers 3 and 7, both surfaces of the photo and thermal sensitive material layer 5 are heated with higher efficiency, thereby enabling a high aspect ratio fine pattern to be formed.

The temperature of the first and second light-to-heat converting layers 3 and 4 may rise above hundreds of Celsius. To prevent problems arising from such a temperature rise, the substrate protective layer 2 is formed on the substrate 1.

In particular, to prevent damage of the target substrate 1 by the heat generated in the first light-to-heat converting layer 3, the substrate protective layer 2 is formed on the surface of the target substrate 1. Suitable materials for the substrate protective layer 2 include inorganic compounds, such as $ZnS \cdot SiO_2$, and organic compounds, such as polyimide. The thickness of the substrate protective layer 2 may be, but

is not limited to, in a range of 50-500 nm, depending on the wavelength of activation light used and the material properties of the substrate protective layer 2. When the target substrate 1 is thermally resistant, the substrate protective layer 2 is unnecessary.

Due to a steep temperature rise by the heat generated in the first and second light-to-heat converting layers 3 and 7, the photo and thermal sensitive material layer 5 may be abruptly deformed, evaporate, or swell. To prevent this, the first and second thermal buffer layers 4 and 6 are formed between the photo and thermal sensitive material layer 5 and the respective first and second light-to-heat converting layers 3 and 7. Materials for the first and second thermal buffer layers 4 and 6 may be the same as materials for the substrate protective layer 2. The thicknesses of the first and second thermal buffer layers 4 and 6 are in a range of 5-100 nm, and preferably, 10-50 nm. The thickness of the first and second thermal buffer layers 4 and 6 influences heat diffusibility and pattern shape. It is preferable that the thickness of the first and second thermal buffer layers 4 and 6 is smaller than a desired pattern size. When the photo and thermal sensitive material layer 5 is thermally resistant or when certain activation light irradiation conditions prevail, the first and second thermal buffer layers 4 and 6 may be not formed. Alternatively, any one of the first and second thermal buffer layers 4 and 6 may be formed if required.

In order to prevent abrupt deformation, evaporation, or swelling of the second light-to-heat converting layer 7 as well as the photo and thermal sensitive material layer 5, the cap layer 10 may be formed on the second light-to-heat converting layer 7. Suitable materials for the cap layer 10 include transparent plastics, transparent glass, dielectric materials, etc. The thickness of the cap layer 10 may be, but is not limited to, in a range of 5-200 nm, and preferably, 10-50 nm. The cap layer 10 may be not formed when the photo and thermal sensitive material layer 5 is thermally resistant or when certain activation light irradiation conditions prevail.

Materials for the target substrate 1 which are compatible with pattern forming materials according to the present invention having the above-described structure include common materials for substrates used to manufacture electronic/electrical parts by general lithography. The target substrate 1 may be an inorganic substrate made of, for example, silicon, tantalum, aluminum, or gallium-arsenic; a glass substrate; or a plastic substrate made of, for example, polypropylene, acrylic resins, polycarbonate, polystyrene resins, or vinylchloride resins. Alternatively, an inorganic substrate made of aluminum, tantalum, silica, etc. or a glass substrate with an aluminum or tantalum layer deposited thereon or with a light curing resin layer coated thereon may be used.

Any material which changes in properties by heat or activation light irradiation and which allows a sharp pattern to appear through development processes can be used for the photo and thermal sensitive material layer 5. Examples of such a material include positive type and negative type photoresists which have been commonly used so far to manufacture electronic/electrical parts by lithography. In addition, electron beam resist that thermally changes can be used.

Any material capable of absorbing light and converting it into heat can be used for the first and second light-to-heat converting layers 3 and 7. Examples of such a material include: Ge-Sb-Te alloys, including $Ge_2Sb_2Te_5$ used for a recording layer of DVD-RAMs; Sb; Ag-In-Sb-Te alloys; Ag-In-Sb-Te-V alloys; lithium niobate; methylnitro aniline, etc.

In the pattern forming materials according to the present invention, the thickness of the photo and thermal sensitive material layer 5 is in a range of 10-1000 nm, and preferably, 50-200 nm. The thicknesses of the first and second light-to-heat converting layers 3 and 7 are in a range of 5-300 nm, and preferably, 10-150 nm. The thickness of the first and second light-to-heat converting layers 3 and 7 is not limited to the above range and is varied depending on the wavelength of activation light used and the material composing the first and second light-to-heat converting layers 3 and 7.

A method of forming a fine pattern using the above pattern forming materials according to the present invention will be described step by step with reference to the appended drawings.

< Embodiment 2 >

FIGS. 3A, 3B, 4C, and 4D are sectional views illustrating a method of forming a fine pattern according to an embodiment of the present invention. In FIGS. 3A, 3B, 4C, and 4D, elements that appeared in previous drawings are designated by the same reference numerals.

Referring to FIG. 3A, pattern forming materials including the first light-to-heat converting layer 3, the first thermal buffer layer 4, the photo and thermal sensitive material layer 5, the second thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 are formed on the target substrate 1, with the substrate protective layer 2 between the first light-to-heat converting layer 3 and the target substrate 1. The photo and thermal sensitive material layer 5 is made of a positive type photoresist. The lens 9 which converges activation light is installed below the target substrate 1.

Referring to FIG. 3B, the activation light 10, for example, a laser beam, is radiated to generate heat in the first and second light-to-heat converting layers 3 and 7 and selectively heat a portion of the photo and thermal sensitive material layer 5 made of a positive type photoresist to form the pattern portion 12, which is no longer photosensitive due to the exposure to heat. Since the photo and thermal sensitive material layer 5 is interposed between the first and second light-to-heat converting layers 3 and 7, both surfaces of the photo and thermal sensitive layer 5 are efficiently heated, thereby enabling a fine high aspect ratio pattern to be formed.

Referring to FIG. 4C, after the thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 are removed, activation light 13, for example, blue light, is radiated over the entire

exposed surface of the photo and thermal sensitive layer 5. As a result, a non-pattern portion 12' around the pattern portion 12 is changed to be soluble in a developing solution through a reaction with the blue light 13. The same result can be obtained when the blue light 13 is radiated before the second thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 are removed.

Next, a development process is performed to remove the non-pattern portion 12' so that only the pattern portion 12 made of resist remains.

The second thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 deposited on the photo and thermal sensitive material layer 5 can be removed by dry etching or wet etching. Suitable dry etching methods include reactive ion etching (RIE), sputtering etching, etc. HF, KOH, HCl, and other kinds of etchant can be used for wet etching. However, the method and etchants which can be used to remove the above layers are not limited to the above.

Various kinds of activation light which are commonly used for fine lithography can be selectively used as a light source in the present invention. In addition, the activation light 10 used in the process of FIG. 3B and the activation light 13 used in the process of FIG. 4C may have different wavelengths or the same wavelength. A suitable activation light source is chosen depending on the properties of the photo and thermal sensitive material used. Suitable activation light sources include visible light, deep UV, I-ray, g-ray, KrF eximer laser, ArF eximer layer, etc.

< Embodiment 3 >

FIGS. 5A, 5B, 6C, and 6D are sectional views illustrating a method of forming a fine pattern according to another embodiment of the present invention. In FIGS. 5A, 5B, 6C, and 6D, elements that appeared in previous drawings are designated by the same reference numerals.

Referring to FIG. 5A, pattern forming materials including the first light-to-heat converting layer 3, the photo and thermal sensitive material layer 5, and the second light-to-heat converting layer 7 are formed on the target substrate 1. In other words, the substrate protective layer 2, the first thermal buffer layer 4, the second thermal buffer layer 6, and the cap layer 8, which are formed in the previous embodiment, may be not formed. Such thermal protective layers and cap layer may be not formed depending on the thermal resistance of the target substrate 1 and the photo and thermal sensitive material layer 5 and activation light irradiation conditions, for example, the intensity of activation light.

Referring to FIG. 5B, the activation light 10, for example, a laser beam, is radiated to generate heat in the first and second light-to-heat converting layers 3 and 7 and selectively heat a portion of the photo and thermal sensitive material layer 5 made of a positive type photoresist to form the pattern portion 12, which is no longer photosensitive due to the exposure to heat. Since the photo and thermal sensitive material layer 5 is interposed between the first and second light-to-heat converting layers 3 and 7, both surfaces of the photo and thermal sensitive layer 5 are efficiently heated, thereby enabling a fine high aspect ratio pattern to be formed.

Referring to FIG. 6C, after the second light-to-heat converting layer 7 is removed, activation light 13, for example, blue light, is radiated over the entire exposed surface of the photo and thermal sensitive layer 5. As a result, a non-pattern portion 12' around the pattern portion 12 is changed to be soluble in a developing solution through a reaction with the blue light 13. The same result can be obtained when the blue light 13 is radiated before the second light-to-heat converting layer 7 is removed.

Next, a development process is performed to remove the non-pattern portion 12' so that only the pattern portion 12 made of resist remains.

< Embodiment 4 >

FIGS. 7A, 7B, 8C, and 8D are sectional views illustrating a method of forming a fine pattern according to another embodiment of the present invention. In FIGS. 7A, 7B, 8C, and 8D, elements that appeared in previous drawings are designated by the same reference numerals.

The processes illustrated in FIGS. 7A, 8C, and 8D are the same as the processes illustrated in FIGS. 3A, 4C, and 4D of the second embodiment described above, and thus descriptions thereon will be not repeated here.

Referring to FIG. 9B, lamp heaters 13 which emit activation light 15 having a long wavelength to heat the target substrate 1 are disposed near the lens 9. Since the photo and thermal sensitive material layer 5 is also heated by the additional lamp heaters 13, a larger amount of heat is generated in the first and second light-to-heat converting layers 3 and 7, and a thermal reaction in the photo and thermal sensitive material layer 5 is facilitated. Accordingly, a smaller amount of activation light 10 can be radiated.

Any heating device can be used for the lamp heaters 13. For example, an electrical heater, such as a resistor heater, may be installed on a support (not shown) of the target substrate 1.

< Embodiment 5 >

FIGS. 9A, 9B, 10C, and 10D are sectional views illustrating a method of forming a fine pattern according to another embodiment of the present invention. In FIGS. 9A, 9B, 10C, and 10D, elements that appeared in previous drawings are designated by the same reference numerals.

The structure of pattern forming materials shown in FIG. 9A is the same as the structure illustrated in FIG. 3A.

After the structure of the pattern forming materials has been formed, as illustrated in FIG. 9B, the activation light 13 is radiated onto

the structure of the pattern forming materials to make the entire photo and thermal sensitive material layer 5 soluble in a developing solution. Alternatively, the activation light 13 may be radiated before the second thermal buffer layer, the second light-to-heat converting layer 7, and the cap layer 8 are formed.

Next, referring to FIG. 10C, the activation light 10, for example, a laser beam, is radiated to generate heat 11 in the first and second light-to-heat converting layers 3 and 7 and selectively heat a portion of the photo and thermal sensitive material layer 5 made of a positive type photoresist to form the pattern portion 12, which is rendered insoluble in a developing solution. In particular, when the activation light 10 is radiated as illustrated in FIG. 9B, protons (H^+) are generated in the photo and thermal sensitive material layer 5 and catalyze a cross-linking reaction of the positive type resist composing the photo and thermal sensitive material layer 5 when heated. As a result, the positive type photoresist is changed to be insoluble in a developing solution. Since the photo and thermal sensitive material layer 5 is interposed between the first and second light-to-heat converting layers 3 and 7, both surfaces of the photo and thermal sensitive layer 5 are efficiently heated, thereby enabling a fine high aspect ratio pattern to be formed.

Next, referring to FIG. 10D, the second thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 are removed.

Next, referring to FIG. 10E, a developing process is performed to remove the non-pattern portion 12' so that only the pattern portion 12 made of resist remains as a fine pattern.

< Embodiment 6 >

Although the above-described embodiments according to the present invention are described as using a positive type photoresist, the same patterning can be performed with a negative type photoresist. An embodiment using a negative type photoresist will be described with reference to FIGS. 11A, 11B, 12C, and 12D. In FIGS. 11A, 11B, 12C,

and 12D, elements that appeared in previous drawings are designated by the same reference numerals.

Referring to FIG. 11A, a structure of pattern forming materials, which is the same as the structure of the pattern forming materials illustrated in FIG. 3A, except that a negative type photoresist is used for the photo and thermal sensitive material layer 5, is formed.

Next, referring to FIG. 11B, the activation light 10, for example, a laser beam, is radiated to generate heat 11 in the first and second light-to-heat converting layers 3 and 7 and selectively heat a portion of the photo and thermal sensitive material layer 5 made of a negative type photoresist to form the pattern portion 12. As a result, the pattern portion 12 is changed to be insoluble in a developing solution.

The processes illustrated in FIGS. 12C and 12D are the same as the processes illustrated in FIGS. 10D and 10E in the fifth embodiment. In other words, the second thermal buffer layer 6, the second light-to-heat converting layer 7, and the cap layer 8 are removed, and the non-pattern portion 12' is removed through a developing process so that only the pattern portion 12 remains as a fine pattern.

As described above, a high aspect ratio fine pattern can be formed with a negative photoresist as well as a positive photoresist.

A more specific embodiment of the present invention is described below. The following embodiment is for illustrative purposes and is not intended to limit the scope of the invention.

< Embodiment 7 >

A structure of pattern forming materials as illustrated in FIG. 3A in the second embodiment was manufactured with a carbonate substrate having a thickness of 600 nm for the target substrate 1, a $ZnS \cdot SiO_2$ layer having a thickness of 200 nm for the substrate protective layer 2, a $Ge_2Sb_2Te_5$ layer having a thickness of 15 nm for each of the first and second light-to-heat converting layers 3 and 7, a $ZnS \cdot SiO_2$ layer having a thickness of 20 nm for each of the first and second thermal buffer

layers 4 and 6, a $ZnS \cdot SiO_2$ layer having a thickness of 20 nm for the cap layer 8, and a positive type photoresist layer (AZ5214-e, available from Clariant Corporation) having a thickness of 70 nm for the photo and thermal sensitive material layer 5. Next, the structure of the pattern forming materials was patterned using the method described in the above second embodiment.

In particular, the target substrate 1 with the pattern forming materials was loaded on a disc, and a laser beam having a wavelength of 635 nm was radiated onto the target substrate 1. An optical system having a numerical aperture of 0.6 and a diffraction limit of 530 nm was used. Due to the diffraction limit, a pattern finer than the diffraction limit cannot be formed when the optical system is used alone without heating.

The structure of the pattern forming materials was rotated at a rate of 6 m/s using an optical disc drive tester and irradiated with laser light at 3 mW during a single turn. Next, a line pattern was drawn by laser irradiation of 300 nm from a position closer to the structure of the pattern forming materials.

A 1% hydrofluoric acid solution was used to remove the cap layer 8 and the second thermal buffer layer 6, and a 1:5 mixture of 10% potassium hydroxide solution and 35% hydrogen peroxide solution was used to remove the second light-to-heat converting layer 7. An organic alkaline solution (NMD-W, available from Tokyo Ohka Kogyo Ltd.) was used as a developing solution,

The resulting fine pattern was observed using an atomic force microscope. The result is shown in FIG. 13. In FIG. 13, the arrows denote the line pattern. As shown in FIG. 13, lines are arranged close together with a line width of 130 nm. The maximum height of a single line is 60nm, which is almost the same as the thickness of the photoresist layer. In addition, the line pattern has a whole shape because there was no evaporation and deformation of the photoresist and has a higher aspect ratio than conventional patterns.

The optical system used in this embodiment, which emits visible

laser light, is more economical than currently available photolithography which uses vacuum UV, X-rays, etc., to form a fine pattern.

While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

Industrial Applicability

According to the present invention, a photo and thermal sensitive material layer with light-to-heat converting layers on its upper and lower surfaces is deposited on a target substrate and subjected to activation light irradiation, so that a fine pattern can be efficiently formed in the photo and thermal sensitive material layer by heat generated via the activation light irradiation, without evaporation or deformation of the photo and thermal sensitive material layer. The resulting fine pattern has a higher aspect ratio compared to when using conventional methods.